Space Weather Technical Forecast

Issued on Thursday 2 January 2025 at 12:20 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares expected, slight chance X-class flares. Chance G1 Minor Storms Days 1 and 3 (02 and 04 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate activity has been observed with three M-class flares, peaking at M1.2 at 01/1817 UTC, from AR3936 on the northwest limb. There are twelve regions on the Earth-facing disc, with AR3936 no longer visible on the west limb but a new region rotating onto the east limb. The new region on the east limb is still difficult to analyse due to the viewing angle. Some growth has been observed on the disc, with AR3945 in the southeast showing rapid growth in its northern spot, although it appears to have a fairly simple magnetic structure at present. Also of interest is AR3944, as while this is a relatively simple bipolar structure, it has developed some intermediate spots. Newly numbered AR3946 in the southwest developed rapidly in the last 24 hours, but has a straightforward magnetic structure. AR3939 in the southwest remains a somewhat complex sunspot, and is just about showing penumbra on the southern spot. This group has a more north-south aligned magnetic structure which could increase instability. Other groups appear fairly simple at the present time.

No Earth directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE and DSCOVR at L1, showed ongoing but waning CME influence. Wind speeds were mostly elevated, varying mainly between 470-500 km/s. Density was above average, perhaps well above average with a peak according to DSCOVR near 100 ppcc. Density has since dropped, and is now near average. Interplanetary Magnetic Field, Bt, was strong until 01/1830 UTC, with a peak of 26nT, then eased to become mostly moderate. The north-south component, Bz, was persistently strongly negative until 01/1620 UTC, with minimum -23nT. It then became weakly northward directed, and is now moderately southward directed. Phi angle was variable. Geomagnetic activity was initially at G2/Moderate Storm, with one G4 Severe Storm interval reported by BGS at 01/1500-1800 UTC. However other centres (Potsdam, SWPC) have reported G3 Strong Storm intervals for 01/1200-1500 and 011800-2100 UTC. Thereafter it became Quiet to Active.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 remained background levels. High energy electron flux (greater than 2MeV) at GOES16 was at background levels with the associated 24 hr fluence well below Active. The 02/0000 UTC fluence observation was 1.13e6 integrated pfu.

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Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected to continue, with a slight chance of isolated X-class flares. This risk declining a little as AR3936 rotates away from the west limb.

Solar Wind / Geomagnetic Activity: There is one potential Earth directed CME, which is expected to pass near Earth early on Day 3 (04 Jan), but with low confidence. Solar winds are currently elevated but easing after the CME arrivals on 31 Dec and 01 Jan. CH05 may then give elevated wind speeds on Days 3-4.

Geomagnetic activity is expected to be Unsettled to Active at first, with a chance of G1/Minor Storm intervals, slowly easing to become Quiet to Unsettled by Day 2 (03 Jan). Any CME arrival on Day 3 could occur alongside the coronal hole enhancement, which brings a potential for Active to G1/Minor Storms on Day 3. There is a slight chance of G2 Moderate storm intervals. Elevated wind speeds continuing into Day 4, but geomagnetic activity is likely to tail off.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is likely to continue at background levels, but with a slight chance of reaching above S1 in response to any larger flares from the western disc. The risk declining a little as AR3936 rotates well away from the west limb. GOES16 high energy electron flux may increase after the recent CME activity, before any further solar wind enhancement suppresses this. The associated fluence is expected to remain below Active, with only a slight chance of rising above.

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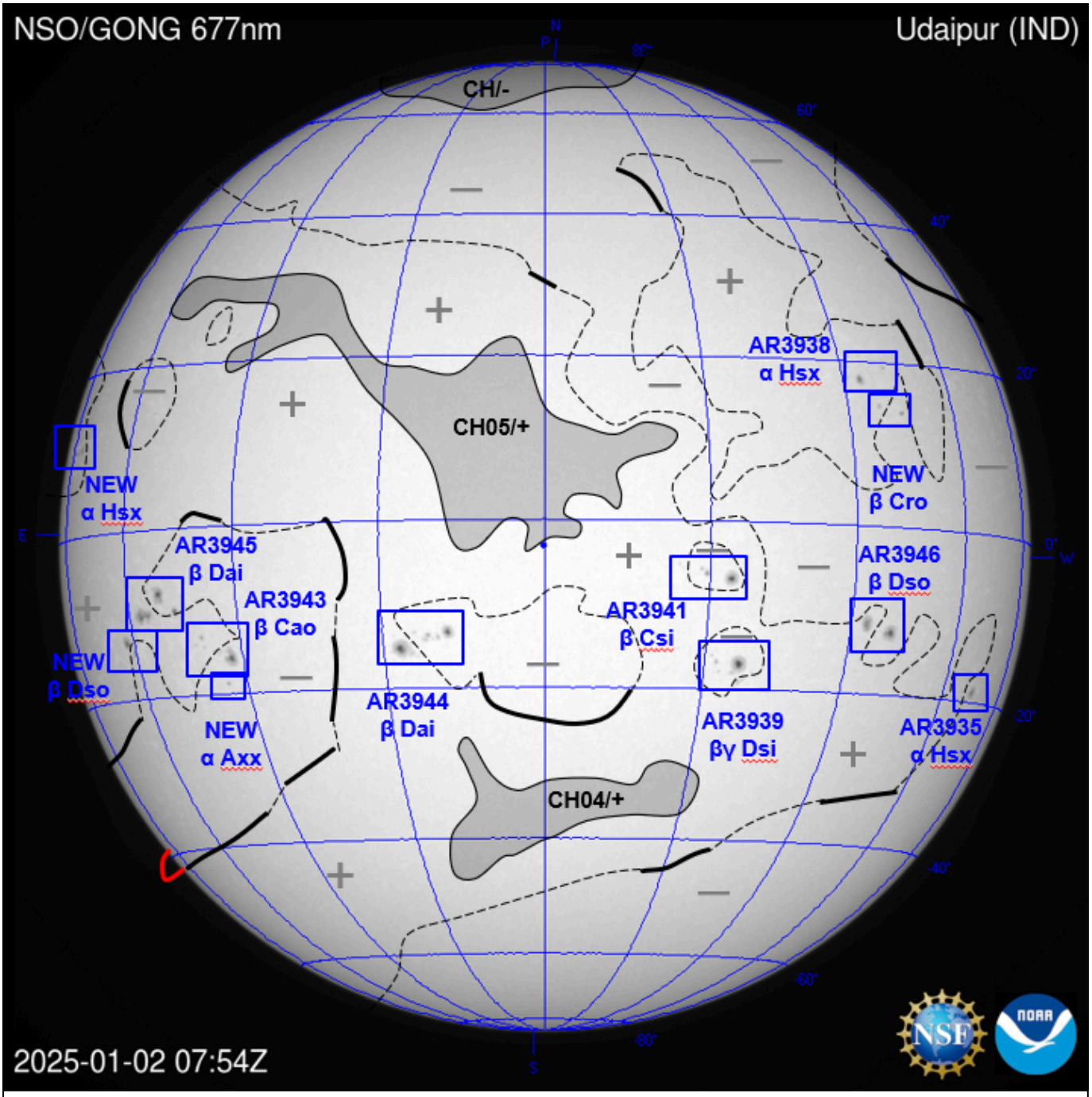
Figure 1: Solar synoptic map valid at 02/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There is one potential Earth directed CME, from a weak filament eruption early on 01 Jan from the vicinity of AR3939. This is expected to pass near Earth early on Day 3 (04 Jan), perhaps missing ahead of Earth's orbit, but with only glancing effects anticipated if it does arrive.

Solar winds are currently elevated but easing after the CME arrivals on 31 Dec and 01 Jan. The other main upcoming features in the forecast are the large positive coronal holes CH04 in the south, and CH05 in the north. These have a similar leading edge, currently around 10-15W. The most likely of these to influence Earth is the northern CH05, as CH04 is likely too far south to have a significant impact. CH05 was smaller and further east on the previous rotation, and was observed on the equivalent of Day 4 (05 Jan), with solar winds of around 500 km/s. Enlil, however, indicates a weak connection to the very southern edge of the feature's fast wind on Day 3. Given the current location and the potential for the feature to be stronger than last rotation, due to being larger this time around, this potential arrival time is currently accepted.

Geomagnetic activity is expected to be Unsettled to Active at first, with a chance of G1/Minor Storm intervals, slowly easing to become Quiet to Unsettled by Day 2 (03 Jan). Any CME arrival on Day 3 could occur alongside the coronal hole enhancement, so despite it not being the most favourable time of year for a strong connection to this feature, this will still bring a potential for Active to G1/Minor Storms on Day 3. There is a slight chance of G2 Moderate storm intervals. Elevated wind speeds continuing into Day 4, but geomagnetic activity is likely to tail off.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	25	5	30	10
Strong	G3	Yes	1	1	1	1
Severe	G4	Yes	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
01/0740	Partial	Filament	South-centre	560	04/0300 UTC (+/- 9hrs)	Low confidence, glancing impact.

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Figure 2: MOSWOC Enlil, showing a potential CME glance early on 04 Jan.

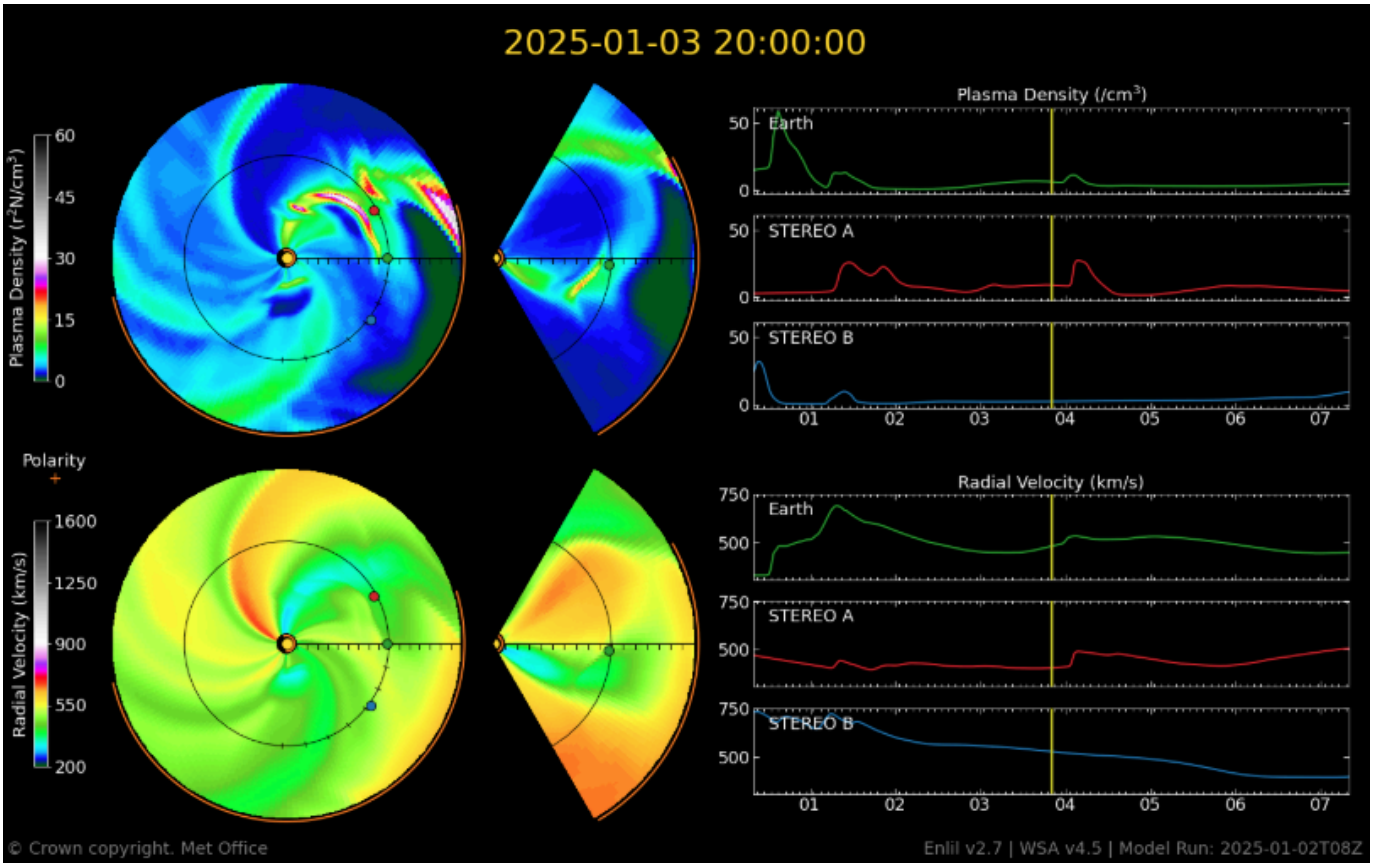

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Figure 3: MOSWOC Enlil ensemble, showing a potential CME glance early on 04 Jan.

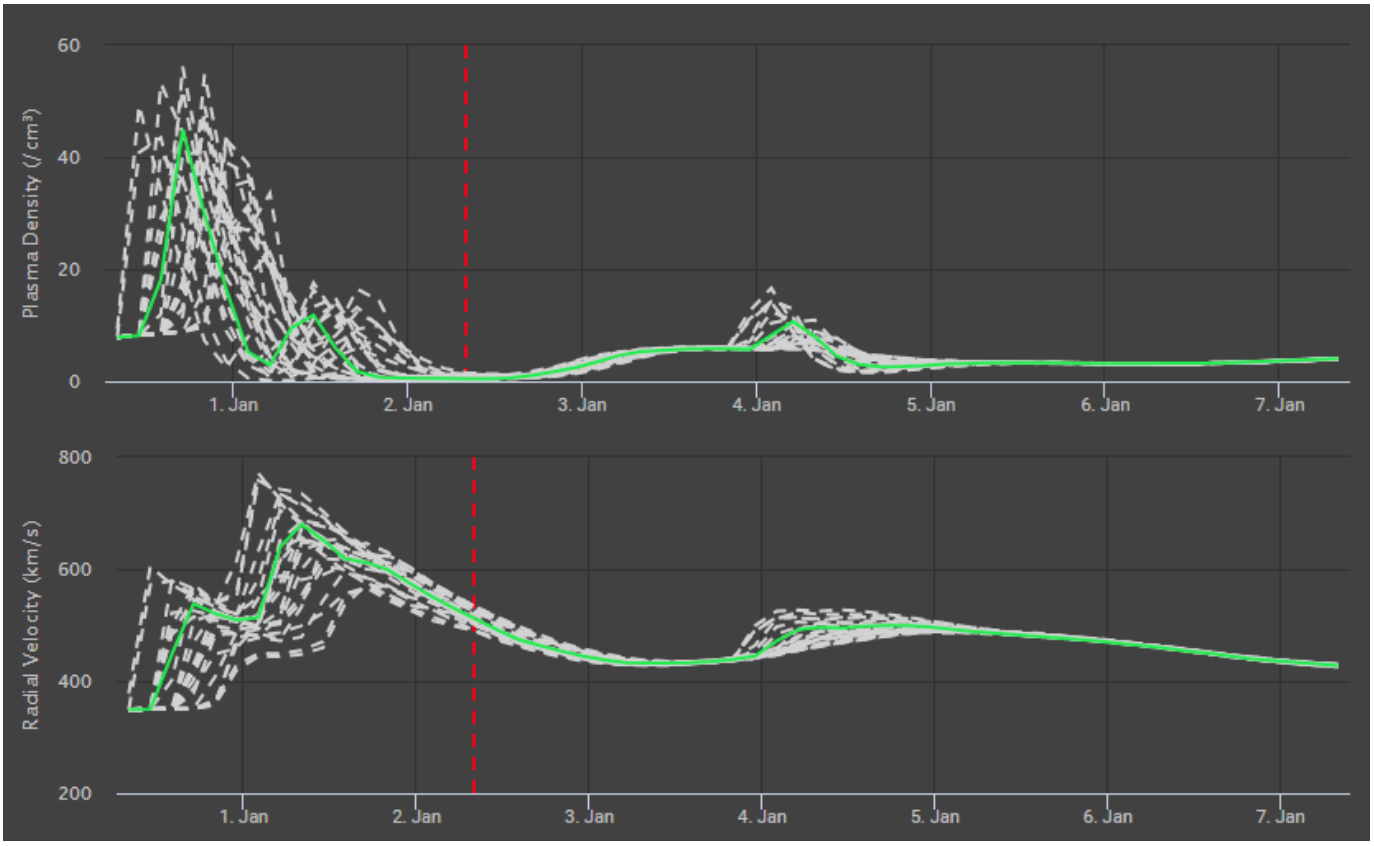
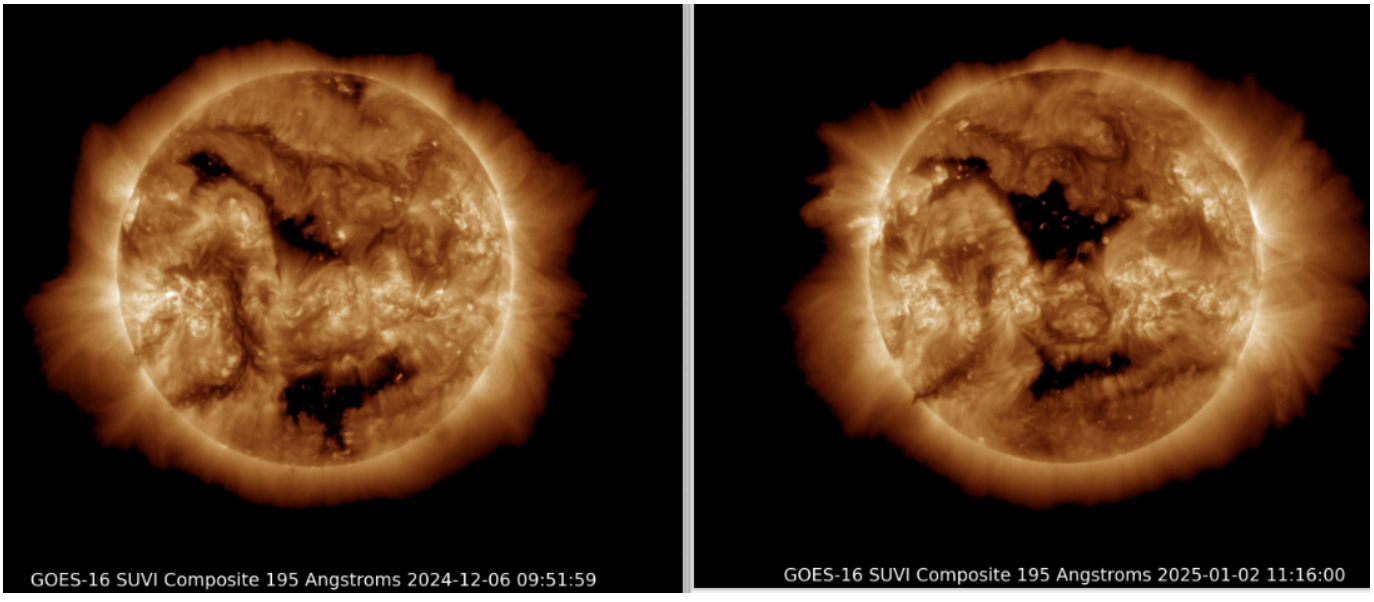


Figure 4: GOES SUVI 195 imagery, showing coronal holes on the previous rotation (left) and current rotation (right). Both have grown, increasing the chances of stronger wind speeds.



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Radio Blackouts - X-Ray Flares

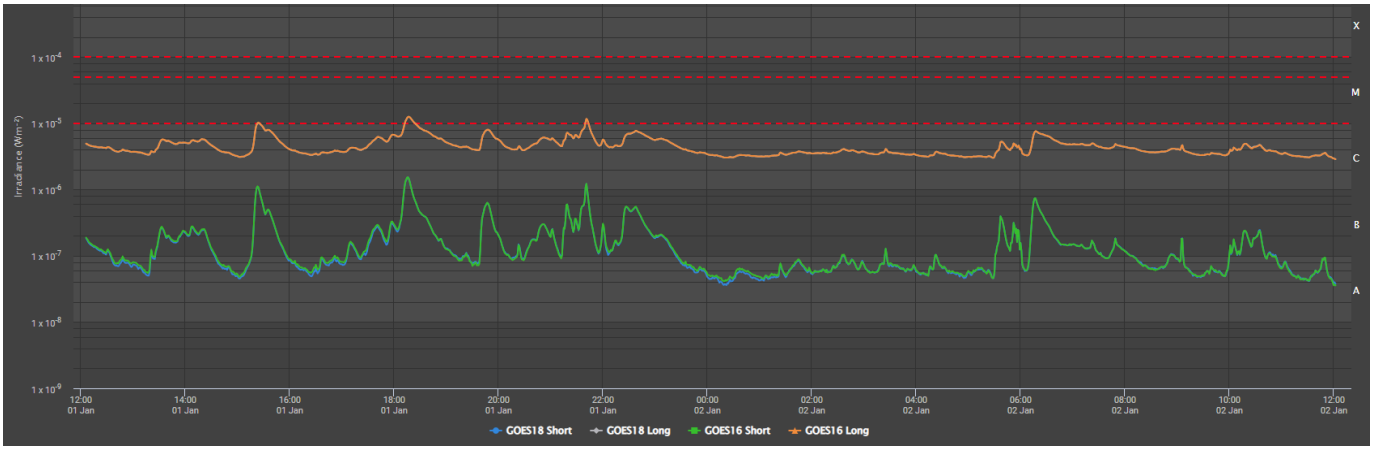
Solar activity has persisted at Moderate levels with three M-class flares, the peak of which was M1.2 at 01/1817 UTC from AR3936 on the west limb.

There are twelve regions on the Earth-facing disc, with AR3936 no longer visible on the west limb but a new region rotating onto the east limb. AR3936 will still contribute to the flare risk for another 24 hours or so. The new region on the east limb is still difficult to analyse due to the viewing angle. Some growth has been observed on the disc, with AR3945 in the southeast showing rapid growth in its northern spot, although it appears to have a fairly simple magnetic structure at present. Also of interest is AR3944, as while this has a relatively simple bipolar structure, it has developed some intermediate spots. Newly numbered AR3946 in the southwest developed rapidly in the last 24 hours, but has a straightforward magnetic structure. AR3939 in the southwest remains a somewhat complex sunspot, and is just about showing penumbra on the southern spot. This group has a more north-south aligned magnetic structure which could increase instability. Other groups appear fairly simple at the present time.

Overall, M-flaring is expected to continue with a slight risk of X-flares, this declining somewhat as AR3936 rotates away from the west limb.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	70	60	60
Very Active	R3-R5 (X Class)	No	15	10	10	10

Figure 5: X-ray trace at GOES16 and 18, showing three low level M-flares in the last 24 hours.



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Solar Radiation Storms (High Energy Protons)

High energy proton flux as observed by GOES-18 is at background levels. There a number of active regions on the Earth-facing disc, including AR3936, which was the source of the most recent X-class flares, and is currently rotating over the northwest limb. Any larger flares, especially from the better Earth-connected western hemisphere, bring a chance of increasing the proton flux, and a slight chance of exceeding the S1 Minor Radiation Storm level. This risk declines slightly through the period as AR3936 rotates further away from the west limb.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	15
Very Active	**≥ S3 ***	No	5	5	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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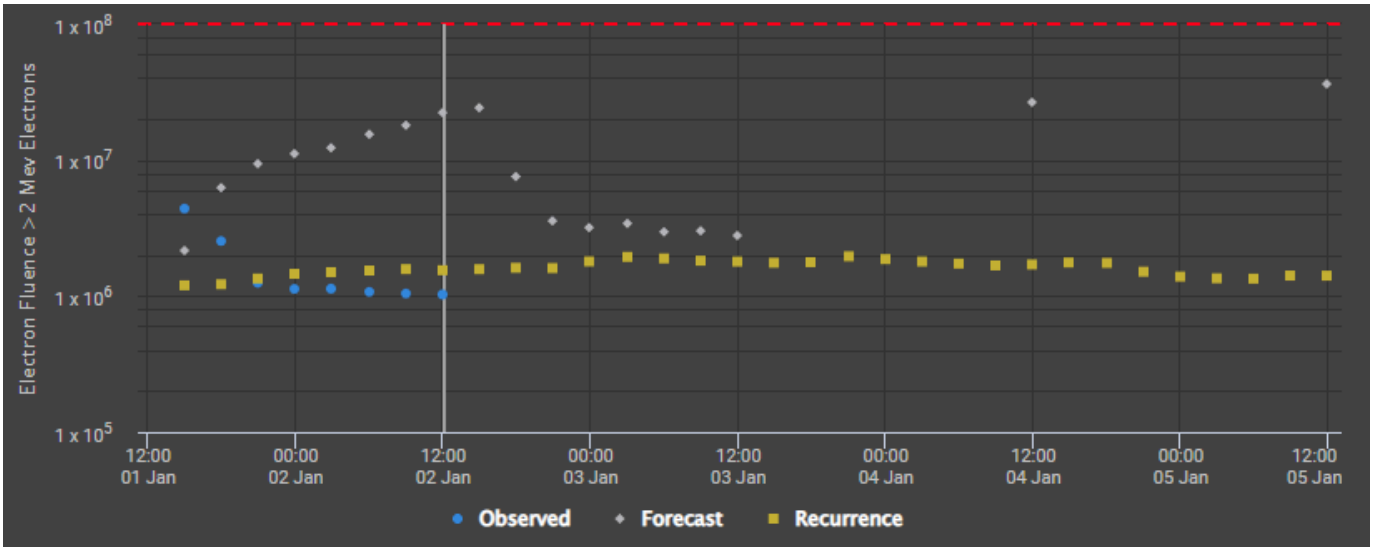
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 is currently at background levels. The recent CME arrival and elevated solar winds may have increased flux at MEO, and as solar wind speeds ease on Days 1-2 (02-03 Jan) the radiation belt is expected to expand outward towards GEO, giving the potential for a period of moderate to high flux. That said, the BAS radiation belt model is not indicating any significant increase in electron flux at lower orbits, so the extent of this is low confidence. The onset of any fast wind from CH05 and the potential CME arrival early on Day 3 (04 Jan) then decreases confidence for the longevity of any enhanced flux, as these would likely drop values back to background, at least for a time. However, once any initial geomagnetic activity eases, the observed flux could rise again day 4 (05 Jan), although this is very low confidence by this time.

Overall the associated 24 hr fluence is most likely to persist below Active, but possibly with a rising trend. This will bring a slight chance for periods of Active fluence, most likely Days 2-3. A rising trend below Active is supported by MOSWOC REFM, which seems like a reasonable trend at this time, although exact values are not to be taken too literally.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	10	15	5
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 6: MOSWOC REFM, showing a rising trend below Active.



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